REMARKS

Applicant appreciates the detailed examination evidenced by the Office Action mailed August 9, 2007 ("Office Action"). Applicant requests reconsideration and withdrawal of the rejections of Claims 1-25 for at least the reasons discussed below.

Independent Claims 1, 4, 17 and 20 are patentable

Independent Claim 1, which stands rejected as allegedly anticipated by U.S. Patent No. 4,533,986 to Jones ("Jones") (Office Action, p. 2.), recites:

> A power converter apparatus comprising a ***multi-resonant*** circuit comprising ***a series-resonant circuit*** and ***a frequency-dependent impedance connected in series with the series-resonant circuit and operative to counteract an inductance of the series-resonant circuit***, a switching circuit operative to alternately apply first and second voltages to an input of the multi-resonant circuit, and a rectifier circuit coupled to an output of the multi-resonant circuit.

Regarding Claims 1-3, the Office Action asserts:

> Jones discloses claimed subject matters a power converter (figure 1-2), including a series -resonant circuit (figure 1-2), a counteract an inductor (column 12, line 1-35), a switching circuit (figure 1, item 27-28), a rectifier (figure 1, item 33-34), and increase in frequency (column 7, line 30-65), a second series resonance circuit (figure 2, 40-41 and 46-46).

Office Action, pp. 2 and 3.

As an initial matter, the Office Action fails to indicate where Jones allegedly teaches "a frequency-dependent impedance connected in series with the series-resonant circuit and operative to counteract an inductance of the series-resonant circuit," as recited in Claim 1. The Office Action refers to "a counteract an inductor," citing column 12, lines 1-35 of Jones. This passage describes an inductor 71 of a booster converter 12' shown in FIG. 4 of Jones, and states:

> . . . This reduces the voltage across the transistor switch at the beginning of its turn-on period, decreasing the switching loss. The inductor need only be a few microhenries (2-6 microhenries) since its function is to provide an impedance only during the switching transient.
>
> The addition of the inductor 71 ordinarily causes an unacceptable overshoot in voltage at the collector of the transistor switch 19 when it is turned off, unless a snubber (72,

> 73, 74) is added across the inductor. The snubber consists of a diode 72 having its anode connected to the collector of transistor 19 (at a first terminal of inductor 71) and its cathode connected to one terminal of capacitor 73. The other terminal of capacitor 73 is connected to the anode of diode 20 (at the other terminal of inductor 71), thus connecting 72/73 series combination in shunt with the inductor 71. A resistor 74 is connected in shunt with the capacitor 73.
>
> The turn-off of transistor switch 19 causes the current flowing from inductor 18 to enter the inductor 71 as diode 20 beings to turn on. The turn-on transient of current in inductor 71 normally elevates the collector voltage of transistor switch 19 at a time before current therein has terminated, stressing the transistor switch. The addition of the "snubber" circuitry (72, 73, 74) provides a low impedance path for inductor 18 current around inductor 71 during this transient and reduces the rise in collector voltage of transistor 19 by diverting a portion of the current transient to the capacitor 73. Resistor 74 provides a discharge path for capacitor 73.
>
> The circuit illustrated in FIG. 4 is of advantage whether employed with a power MOSFET or a bipolar transistor. In general, the MOSFET outperforms the state of the art bipolar under these circumstances.

There appears to be nothing in this passage that corresponds to "a frequency-dependent impedance connected in series with the series-resonant circuit and operative to counteract an inductance of the series-resonant circuit."

Moreover, the circuit shown in FIGs. 1 and 2 of Jones do not appear to include any corresponding to a "multi-resonant" circuit. FIG. 1 of Jones shows a converter having a series resonant converter 14 including a resonant circuit with a single resonant frequency, i.e., the resonant frequency of the series combination of the inductance of the transformer 32 and the capacitors 29 and 20. Similarly, FIG. 2 of Jones shows a resonant converter including a resonating circuit including an inductor 46 and capacitor 45 coupled in series and having a single resonant frequency. *See* Jones, column 9, lines 2-7. Neither of these circuits appear to be "multi-resonant" and neither appear to include "a series-resonant circuit and a frequency-dependent impedance connected in series with the series-resonant circuit." Accordingly, Applicant submits that Jones fails to disclose or suggest several of the recitations of Claim 1.

For at least these reasons, Applicant submits that independent Claim 1 is patentable and request that the rejection thereof be withdrawn. It appears that the Office Action rejects independent Claim 17 on the same basis as independent Claim 1. Office Action, p. 4. Applicant submits that independent Claim 17 is patentable over Jones for at least reasons

similar to those discussed above with respect to independent Claim 1. Should other grounds be asserted for rejecting independent Claim 17 in a subsequent office action, Applicant requests more specific indication of the grounds for rejection.

Independent Claim 4, which stands rejected as allegedly unpatentable over a combination of U.S. Patent No. 5,999,417 to Schlect ("Schlect") and U.S. Patent No. 4,128,868 to Gamble ("Gamble") recites:

> A power converter apparatus, comprising:
> a multi-resonant circuit comprising ***cascaded first and second series-resonant stages having respective first and second resonant frequencies***;
> a switching circuit operative to alternately apply first and second voltages to an input of the multi-resonant circuit; and
> a rectifier circuit coupled to an output of the multi-resonant circuit .

The Office Action concedes that Schlect "does not disclose the utilization of the technique for a cascaded series-resonant stage," but asserts that Gamble provides such teachings at column 4, lines 1-30 and column 7, lines 5-35 thereof, and that "[i]t would have been obvious . . . to modify Schlect's power supply by utilizing the technique taught by Gamble for the purpose of reduction of the step-up ratio of the transformer, making a lighter and more easily constructed transformer." Office Action, p. 3.

Referring to the cited passages from Gamble, column 3, line 53 through column 4, line 35, which includes the first cited passage, states:

> At the conclusion of the application of negative current to terminal A of PA responsive to PDM demanding current, bleeder resistor R1 resumes supplying positive current to terminal A, biasing Q3 into conduction and Q4 out of conduction. With no collector current being demanded by Q4, R5 pulls up the base electrode of Q2 to halt its conduction. R5 is made of sufficiently low resistance that a substantial portion of the stored change is swept out of Q2 during the transition time between conduction in Q4 being terminated and conduction in Q3 being begun. This transition time comes about because terminal A has to swing about 1.4 volt each time there is a transition from conduction in one of transistors Q3 and Q4 and conduction in the other, and before this transition can occur the charge stored in the capacitance associated with terminal A has to be charged in the proper sense. This capacitance will in appreciable part be due to the junction capacitances of the emitter-base junctions of transistors Q3 and Q4 and the stored charge associated with them. R4 is included in the collector connection of Q4, to reduce the thermal dissipation the transistor must be capable of, by reducing the emitter-to-collector voltage of Q4

during its conduction. This permits Q4 to be a less expensive type of transistor and to be physically smaller.

The cascade connection of Q5, Q1 is purposely used rather than a single grounded-emitter NPN transistor to avoid the saturated clamp to ground such an alternative configuration would provide. As current flows into the resonated primary winding of SUT through diode D9 the potential at terminal B drops 0.7 volt below ground. With its collector 0.7 volts negative with respect to its emitter, a grounded-emitter NPN used in lieu of Q1 would be placed into a highly saturated condition, where the entirety of its base current drive would contribute to storing charge in its collector-base junction. When Q2 attempted to apply a +50 volt peak-to-peak output pulse to terminal B, this excessive stored charge would have to be swept out of the NPN in order to turn it off and this would adversely affect its turn-off time. There would be a loss of efficiency due to a high "shoot-through" current through Q2 and the grounded-emitter NPN during any long turn off time of the NPN that increases the overlap in the periods of conduction of the NPN and Q2. Such loss in efficiency would be substantially greater than the loss in efficiency in the circuit shown, which loss of efficiency in the circuit shown results from the PNP Q1 being able to pull the output terminal B of PA only as close to ground as the combined emitter-to-collector saturation voltage of Q5 and base-to-emitter offset potential of Q1 permits.

Column 7, lines 3-38 of Gamble, which includes the second cited passage, states:

. . . Capacitors C13, C14 and C15 provide appropriate noise-filtering and phase-compensation in the feedback networks used to develop control voltage for application to pin 4.

When the regulated supply is first put into operation PA responds to the PDM to place a somewhat less than 50% duty-cycle square-wave pulse on point B with timing corresponding to the synchronizing pulse. Insofar as control of the frequency at which the d-c converter is operated, the system is open-loop. Because of this, the primary winding is tuned to the repetition rate of the synchronizing pulses. In a series-resonant system driven from a low-impedance sine-wave voltage source, the voltage across the coil is Q times the driving voltage. In a series resonant system driven from a low-impedance rectangular-pulse-voltage source, the voltage across the coil is Q times the fundamental component of the rectangular pulse. The fundamental component of a rectangular pulse is known from Fourier wave analysis to be $(2A/\pi)/\sin(\pi\, t_0/T)$ where A is the peak-to-peak amplitude of the pulse and (t_0/T) is its duty cycle. A 50 volt square-wave will have a 63.7 volt peak-to-peak sine wave fundamental, and with a Q of 30 or so, the sinusoidal voltage across the primary winding of the step-up transformer SUT, upon which the 50 volt rectangular pulse will be super-imposed near the zero-crossing, will attempt to grow to some 1900 volts peak-to-peak. This growth is checked by the control voltage at pin 4 of the pulse duration modulator PDM increasing in positive value as the +10KVDC terminal rises in potential; the increasingly positive control voltage narrows the pulse applied to the input terminal A

> of the pulse amplifier PA, responsive to which the 50 volt peak-to-peak pulses supplied at its output terminal B are correspondingly narrowed.

While the first cited passage mentions a "cascade connection of Q5, Q1" and the second passage mentions "a series-resonant system driven from a low-impedance sine-wave voltage source" and "a series resonant system driven from a low-impedance rectangular-pulse-voltage source," these passages do not disclose or suggest ***cascaded first and second series-resonant stages having respective first and second resonant frequencies***, and nowhere else does Gamble appear to disclose or suggest such recitations. Accordingly, the cited combination of Schlect and Gamble fails to disclose or suggest all of the recitations of independent Claim 4.

For at least the foregoing reasons, Applicant submits that independent Claim 4 is patentable and that the rejection thereof should be withdrawn. It appears that the Office Action rejects independent Claim 20 on the same basis as independent Claim 4. See Office Action, p. 4. Applicant submits that independent Claim 20 is patentable for at least reasons similar to those discussed above with respect to independent Claim 4. Should other grounds be asserted for rejecting Claim 20 in a subsequent office action, Applicant requests more specific indication of the grounds for rejection.

The dependent claims are patentable

Applicant submits that dependent Claims 2, 3, 5-16, 18, 19 and 21-24 are patentable at least by virtue of the patentability of the respective ones of independent Claims 1, 4, 17 and 20 from which they depend. Applicant further submits that several of the dependent claims are separately patentable.

For example, Claim 2, which stands rejected as allegedly anticipated by Jones (Office Action, p.2), recites "wherein the frequency-dependent impedance decreases with an increase in frequency at which the first and second voltages are applied to the multi-resonant circuit." The Office Action asserts that Jones teaches "an increase in frequency (column 7, line 30-65)." Office Action, p. 3. The only "increase in frequency" described in this passage is "[i] the voltage across the IC changes in respect to a reference internal to the IC, the square wave output frequency will increase (or decrease)." Jones, column 7, lines 54-56. This does not disclose or suggest the recitations of Claim 2. Accordingly, Jones does not disclose or

suggest the recitations of Claim 2 and, for at least these reasons, Applicant submits that Claim 2 is separately patentable. At least similar reasons support the separate patentability of Claim 19.

Claim 3, which also stands rejected as allegedly anticipated by Jones (Office Action, p. 2), recites "wherein the frequency- impedance comprises a second series- resonant circuit." The Office Action asserts that Jones teaches these recitations at figure 2, 40-41 and 45-46. Office Action, p. 3. These items are, respectively, components of a capacitive energy storage stage 13' (capacitors 40, 41) and a series-resonant half bridge converter 14' (capacitor 45 and inductor 46). The capacitors 40, 41 are not part of a series-resonant circuit; they are storage capacitors. As discussed above, the series resonant circuit 14' only has a single series resonant circuit, comprising the capacitor 45 and the inductor 46. None of these components serves as a "second series-resonant circuit" connected in series with the first series-resonant circuit recited in Claim 1, from which Claim 3 depends. Accordingly, Jones does not teach the recitations of Claim 3 and, for at least these reasons, Applicant submits that Claim 3 is separately patentable. At least similar reasons support the separate patentability of Claim 18.

Regarding dependent Claims 5-16, the Office Action makes cryptic reference to "a first and second transformer (figure 2, item T1 and T2), a resonant frequency (Gamble's column 1, line 20-30), a diode rectifier circuit (Schlect's figure 2, time D3 and D4). Respectfully, the rejections of these claims are impermissibly vague, as no specific indication is provide as to which of dependent claims these allegations pertain. The cited material relating to an alleged teaching of "a resonant frequency" provides no teaching, for example, of "wherein the first resonant frequency is less than the second resonant frequency," as recited in Claim 5, or "wherein the first series-resonant stage is configured to allow the second series-resonant stage to operate at the second resonant frequency while maintaining inductive loading of the switching circuit." None of the cited material appears to pertain to the recitations of Claims 7 and 8 relating to a clamping circuit, or the detailed circuit arrangements recited in Claims 9-13. Claim 14 recites "wherein the multi-resonant circuit comprises a series combination of a first capacitor, first and second primary windings of respective first and second transformers, and a second capacitor; and wherein the rectifier circuit comprises a self-driven synchronous rectifier circuit coupled to first and second

secondary windings of the first and second transformers." None of the cited material discloses or suggests such an arrangement.

For at least these reasons, Applicant submits that at least the above-mentioned ones of dependent Claims 5-16, and corresponding claims of dependent Claims 21-25, are separately patentable. Should the rejections of these claims be maintained, Applicant respectfully requests provision of specific bases for the rejections, and that the rejections not be made final to afford Applicant sufficient opportunity to respond to the rejections.

Conclusion

Applicant respectfully submits that all of the claims are in condition for allowance, and requests allowance of the claims and passing of the application to issue in due course. Applicant urges the Examiner to contact Applicant's undersigned representative at (919) 854-1400 to resolve any remaining formal issues.

Respectfully submitted,

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